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METHOD FOR THE PRODUCTION OF AND PROTECTIVE LAYER FOR A LAYER OF LUMINESCENT MATERIAL

Luminophore layers that operate as storage film (i.e. that store x-ray information) can be used for generation of x-ray exposures. Such storage films are in particular used in digital radiography and mammography. The x-ray information comes about in that the body to be examined is traversed by x-ray radiation. After this irradiation, the x-ray radiation impinges on the storage film where it effects changes on storage elements integrated into the storage film. The number of the storage elements thereby set depends on the intensity of the impinging x-ray radiation. Due to the spatial distribution of the storage cells across the storage film, an x-ray exposure with the size of the exposed part of the storage film thereby results.

The storage elements of the storage film must be read out for generation of electrically-processable image data or image data visible to the human eye. The contents of the storage elements can be optically established. For readout, they are radiated with light of a specific wavelength and thereby optically excited. Such an excited storage element emits light of a specific wavelength in the event that it was charged or set beforehand via the absorption or x-ray radiation. The intensity of the emission light thereby depends on the number of set storage elements and therefore forms a measurement for the previously-absorbed x-ray radiation. The emission light is of a relatively lower intensity and is therefore measured with high-sensitivity detectors, for example with photomultipliers.

The exposes storage film is read out pixel for pixel to generate an x-ray exposure. Electronic image data or image data perceivable by the human eye are generated from the read-out information. Due to the optical readout of the storage film, very high requirements must be placed on the uniformity of the film surface. Defects in the storage film affect not only the readout capability of the storage film but rather also the capability of engaging the storage cells via x-ray radiation. They reduce

the achievable image quality in both events. The achievable image quality therefore significantly depends on the freedom from defects.

Storage films are exposed to various mechanical stresses in x-ray diagnostic applications. For example, they are used in film cassettes in order to generate diagnostic x-ray exposures in medicine. Film cassettes are used in what are known as over-table apparatuses in which the patient to be examined is irradiation by x-ray radiation from above, whereby he lies on the cassette. He thereby exerts a two-dimensional pressure on the cassette and therewith on the storage film. The storage film is mechanically stressed.

Moreover, contact with the patient leads to the creation of moisture on the surface of the storage film. Not least, the surface must be cleaned from time to time with a fluid-saturated cloth in order to remove adhering contaminants which likewise lead to the attachment of moisture. The quality of the storage film also suffers under the increase of the humidity.

Primarily what are known as needle image plates (NIP), in which the luminophore is grown on a substrate in needle-shaped structures, are used as storing luminophore layers. The needle tips of these structures end in the surface of the storage film and influence the x-ray sensitivity and storage capability of the film. Given support of the patient or subject to be examined on a needle image plate, the needle ends situated in the surface are mechanically stressed and can thereby be deformed. The x-ray sensitivity and the storage capability suffer under the deformation. Needle image plates therefore require a particularly effective mechanical surface protection.

From DE 100 48 810 A1, it is known to protect the surface of needle image plates in that a deformable damping layer is applied on the film surface. The damping layer thereby effects a uniform distribution of mechanical loads and must, for its part, be protected from scratches in order to not lose optical quality. For this

purpose, it is proposed to apply a further cover layer made from SiO_2, Al_2O_3, TiO_2 or made from silicate. While the damping layer itself exhibits good bonding properties with the needle image plate, upon application of the further cover layer bonding problems occur with the cover layer that are only to be remedied via extremely elaborate production methods – if at all. Should a parylene layer (poly-para-xylylene) be used as a damping layer due to its excellent properties, a sufficient bonding of the cover layer has not been achieved at all so far.

The object of the invention is to specify a protective layer for a luminophore layer for x-ray exposures that offers excellent protection, both against mechanical loads and against humidity, exhibits a good layer bonding and at the same time can be produced in an uncomplicated manner and cost-effectively. A further object of the invention is to specify a production method for such a protective layer.

The invention achieves these objects via an apparatus with the features of the first patent claim and via a method with the features of the sixth patent claim. A basic idea of the invention is to provide a polymer protective layer that is hardened and in fact in a region that does not abut the luminophore layer. By luminophore layer, what should thereby be understood are both storing and non-storing luminophore layers. Polymer protective layers have the advantage that, for the most part, good bonding properties with luminophore layers can be achieved. Moreover, they can be produced in an uncomplicated and cost-effective manner. Furthermore, a sufficient resilience against mechanical loads and against scratches is ensured by the hardness of the polymer. Likewise, uncomplicated and cost-effective methods are available for hardening such as, for example, electron beam hardening. Moreover, the polymer most notably forms an effective barrier against moisture in the non-hardened region. The only partially-hardened polymer protective layer therewith integrates protection against moisture and against mechanical stresses and simultaneously ensures a layer design that can be produced in a simple, durable and uncomplicated manner.

In an advantageous embodiment of the invention, the hardening of the region of the protective layer not abutting the luminophore layer ensues via electron beam treatment. Electron beam treatment is can be realized in a cost-effective and uncomplicated manner and moreover offers the advantage that the parameters of the electron beam about to which depth the irradiated layer is treated (and therewith hardened) can be set very exactly. The region of the protective layer that should not be hardened can thereby be set very exactly.

Further advantageous embodiments of the invention are the subject matter of the dependent patent claims.

Exemplary embodiments of the invention are subsequently explained using Figures. Thereby shown are:

Figure 1 layer design according to the invention,

Figure 2 production method according to the invention.

Figure 1 shows a layer design according to the invention. Shown is the protective layer 1 that lies over the luminophore layer 3. The luminophore layer 3 is applied on a substrate 5 on which it can be imprinted or vapor-deposited. It can be an arbitrary luminophore layer; in the invention a needle image plate is used. For example, CsBr:Eu, RbBr:Tl or CsBr:Ga are used as storage luminophores, while CsI:Na or CsI:Ti are considered as non-storing luminophores, for example. In particular the storage luminophores that are preferably used for needle image plates number among the alkali halogenides and can take damage via moisture.

The material of the protective layer 1 is a polymer with suitable mechanical and moisture-resistant properties. A parylene layer is preferably used that exhibits suitable protective properties and can be hardened via temperature or electron beam treatment. The three parylene types N (poly-para-xylylene), C (chlorine-

poly-para-xylylene) or D (di-chlorine-poly-para-xylylene) are particularly suitable for the electron beam treatment. The thickness of the parylene layer amounts to 8 to 80 µm. They can be imprinted, spun out (distribution of the fluid parylene via centrifugal force due to rotation) or vapor-deposited.

The protective layer 1 comprises a region 7 that does not abut on the luminophore layer 3 and a region 9 that abuts on the luminophore layer 3. The non-abutting region 7 is hardened in order to form a surface resistant against mechanical stresses or scratches.

The hardening can be achieved in an uncomplicated manner by means of conventional methods such as temperature or electron beam treatment. However, the temperature treatment requires temperatures of at least 200-250°C that would lead to re-crystallization of the luminophore layer 3 lying underneath. Moreover, the temperature treatment exhibits the disadvantage that the layer depth range in which it acts cannot be set well. This is disadvantageous since the hardened region of the protective layer is more permeable to moisture than the non-hardened region. The residual of a non-hardened region of the protective layer 1 of a thickness of at least 5 µm is therefore essentially important to achieve the protective function against moisture. Due to the better adjustability of the parameters, the region 7 not abutting on the luminophore layer 3 is therefore preferably hardened via electron beam treatment. The electron beam treatment allows the exact adjustment of the layer depth to be treated. The treated region 7 preferably exhibits a thickness of at least 3 µm in order to ensure sufficient scratch protection of the surface.

Via the hardened region 7 and the non-hardened region 9, the protective layer 1 integrates protection against mechanical stress and scratches and against moisture. At the same time, it can be applied with good layer bonding to the luminophore layer 3 underneath and represents a particularly simple (because it is one piece) layer design.

Figure 2 shows a manufacturer method according to the invention. It is thereby assumed that the luminophore layer 3 is already present on the substrate 5. It thereby plays no role whether it is a storing or a non-storing luminophore layer.

The surface of the luminophore layer 3 is pre-treated in method step 11 in order to offer good properties for the vapor deposition of the protective layer 1. The pre-treatment ensues via what is known as plasma etching in which the surface is fired upon with ions from a plasma. This plasma treatment on the one hand provides for a cleaning of the surface at the atomic or, respectively, molecular level; on the other hand it effects a micro-roughening of the surface that promotes a good layer bonding.

The polymer protective layer 1 is vapor-deposited in a subsequent method step 13. Pressure, spin or evaporation methods are considered as vapor deposition methods. A chemical vapor deposition method (CVD) is preferably used. The CVD method can if necessary be physically supported, for example via heat (physically enhanced CVD, PECVD method). CVD methods ensure excellent layer bonding and layer properties.

The protective layer 1 is treated by means of electron beam in a subsequent method step. An electron beam of a specific energy is thereby moved with a specific speed over the surface of the protective layer 1. The parameters of the electron beam and its movement over the protective layer influence the thickness of the region 7 of the protective layer 1 that is treated. The electron beam treatment effects a hardening of the protective layer 1 and increases its scratch resistance.

In a first example, a parylene layer of the type N with a total thickness of 50 µm is treated. For this, an electron beam of 40 keV is moved over the parylene layer by means of an electromagnetic x-y deflection. The speed it [sic] electron beam is adjusted such that the uppermost 20 µm of the layer are hardened. Since a

plurality of further quantities influence the depth of the treated region 7, the speed of the electron beam cannot be exactly predetermined but rather must be determined experimentally.

In a second example, a parylene layer of the type C with a total thickness of 30 µm is treated. For this, an electron beam of 25 keV is moved over the parylene layer by means of x-y deflection so quickly that the uppermost 5 µm are hardened.

In a third example, a parylene layer of the type D with a total thickness of 20 µm is treated by an electron beam of 15 keV such that the uppermost 10 µm are hardened.

In a fourth example, a parylene layer of the type C with a total thickness of 8 µm is treated by an electron beam of 5 keV such that the uppermost 3 µm are hardened.

In addition to an electromagnetic deflection of the electron beam, for example, a mechanical feed of the layer can also be used for the movement of the electron beam relative to the protective layer.